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THE STRUCTURE OF ATOMS, AND THE EVOLUTION OF THE ELEMENTS AS RELATED TO THE COMPOSITION OF THE NUCLEI OF ATOMS[1]

THE general theory of the structure of the atom which seems to be most closely in harmony with the facts is that developed by Rutherford. His theory assumes that the atom consists of a central nucleus or sun, and that the satellites of the miniature solar system are the negative electrons. The central nucleus is supposed to contain almost all of the mass of the atom, and is charged with positive electricity. That this nucleus is very minute in comparison with the size of the atom is indicated by the work of Rutherford, of Geiger and Marsden, and of Darwin, who find that the deflection of alpha particles, which are shot from radioactive atoms at speeds which approach 20,000 miles per second and so pass directly through other atoms, is of such a character as to indicate that the positive charge of the atom is very highly concentrated. Thus Darwin's work indicates that the maximum diameter of the nucleus of a hydrogen atom (1.7×10^{-13} cm.) is only about one-one hundred thousandth of the diameter usually assumed for the atom. On this basis the atom would have a volume a million-billion times larger than that of its nucleus, and thus the nucleus of the atom is much smaller in com-

[1] Address presented at the Symposium on the Structure of Matter at the New York meeting of the American Association for the Advancement of Science. A bibliography will be found in the following papers: *Jour. American Chemical Society,* 37, 1367–1421 (1915), 39, 856–879 (1917); *Philosophical Magazine,* 30, 723–734 (1915).

parison with the size of the atom than is the sun when compared with the dimensions of its planetary system.

The special modification of Rutherford's theory which has met with the most success is that due to Bohr. The very remarkable features of this theory have been made the subject of Professor Millikan's address, which has already been given, so they need not be mentioned here. However, in spite of its success, Bohr's theory possesses in common with the other special views of atomic structure which have been developed, the limitation that its application has been restricted to one special class of phenomena, those of radiation, and that it is too simple to give a mechanism which will act as any except the most simple of atoms. In the Bohr atom the negative electrons external to the nucleus are all supposed to lie in the same plane with the nucleus, while the structural relations of organic molecules seem to indicate that at least the outer electrons do not lie in a plane (except when only two in number) but that they have a three-dimensional arrangement.

It was found by Moseley that if the elements are arranged in order according to their X-ray spectra, they fall in the same order as they do in the periodic system. If arranged in this way, beginning with hydrogen as 1, and helium as 2, they are said to be arranged according to their atomic numbers. In our ordinary system of elements there are in all 91 elements from helium to uranium inclusive, and in addition to these there is hydrogen which makes 92 in all. Of these 86 or 87 have been discovered and 6 or 5 remain to be found. It is the purpose of this paper to present some relations which have been found by the writer and his students, which have a bearing on the structure of the atoms of these elements, upon the problem of their stability, and their formation by evolution.

1. Are the Elements Intra-atomic Compounds of Hydrogen?

One of the first suggestions in regard to the structure of the atom was made by Prout in 1815, or a little over a century ago. Prout found, on the basis of his own experiments and the more accurate work of Gay-Lussac, that if the atomic weight of hydrogen was put as 1.00, the atomic weights of the other elements became whole numbers as follows:

PROUT'S ATOMIC WEIGHTS (1815 A.D.) (WITH THE 1915 ATOMIC WEIGHTS ON HYDROGEN BASIS IN PARENTHESES)

Hydrogen	1.0	(1.000)
Carbon	6	(11.91)
Nitrogen	14	(13.90)
Phosphorus	14	(30.78)
Oxygen	16	(15.88)
Sulphur	16	(31.82)
Calcium	20	(39.76)
Sodium	24	(22.82)
Iron	28	(55.41)
Zinc	32	(64.86)
Chlorine	36	(35.46)
Potassium	40	(38.80)
Barium	70	(136.31)
Iodine	124	(125.94)

If Prout's atomic weights had proved exactly correct, his claim that hydrogen is the protyle (πρώτη ὕλη) or fundamental element, might have seemed justified, but when it was found that these weights were very far from correct his hypothesis was largely discarded.

The prejudice which existed a few years ago against Prout's idea is well shown by a quotation from von Meyer's "History of Chemistry," printed in 1906.

> During the period in which Davy and Gay-Lussac were carrying on their brilliant work, and before the star of Berzelius had attained to its full luster, a literary chemical event occurred which made a profound impression upon nearly all the chemists of that day, viz., the advancement of Prout's hypothesis. This was one of the factors which materially depreciated the atomic doctrine in the eyes of many eminent investigators. On ac-

count of its influence upon the further development of the atomic theory this hypothesis must be discussed here, although it but seldom happens that an idea from which important theoretical conceptions sprang, originated in so faulty a manner as it did.

However, a careful study of the most accurately determined of the recent atomic weights reveals some very remarkable relationships. If first of all we make the assumption, as a subject for argument, that the heavier atoms are built up from hydrogen atoms, then it is found that the atoms are in nearly all cases lighter than they should be on the basis of such an hypothesis. Thus, if the following atoms of low atomic weight are considered, it is found that nearly all of them weigh 0.77 per cent. too little.

TABLE I

Atom of	Atomic Weight	Difference from a Whole Number	Per Cent. Variation
Helium......	3.97	−0.03	−0.77
Boron.......	10.92	−0.08	−0.77
Carbon.......	11.91	−0.09	−0.77
Nitrogen......	13.90	−0.10	−0.70
Oxygen.......	15.88	−0.12	−0.77
Fluorine......	18.85	−0.15	−0.77
Sodium.......	22.82	−0.18	−0.77

Therefore, if these atoms are built from hydrogen atoms, there must be during their formation a loss in weight, and presumably in mass, equal to 0.77 per cent. This will be called the "packing effect." When all of the 26 elements from helium of atomic number 2, to cobalt (No. 27) are considered, it is found that with the exception of the four elements, beryllium, magnesium, silicon, and chlorine, which have atomic weights higher than the corresponding nearest whole numbers, the average packing effect of the elements is again −0.77 per cent. This constancy of the packing effect suggests that the variation is due to some single cause, though the four exceptional cases cited above, show that there is undoubtedly some other complicating factor. The discovery by Thomson and Aston that the similar exceptional case of neon is due to the admixture of an isotope of higher atomic weight suggests that it may not be impossible to find a cause for the exceptional behavior in the four other cases.

It has formerly seemed difficult to explain why the atomic weights referred to oxygen (16.00) as a basis are so much closer to whole numbers than those referred to hydrogen as 1.00, but the explanation is indeed very simple from the point of view presented here. The closeness of the atomic weights on the oxygen basis to whole numbers, is indeed extremely remarkable. Thus for the eight elements from helium to sodium the average deviation is only 0.02 unit, or less than the average probable error of the atomic weight determinations, and for all of the first 27 elements the average deviation from a whole number is, though more, increased only to 0.09 unit, when the *sign* of the deviation is considered. If it is *not* considered the deviation is reduced to 0.01 unit for 21 elements. The probability that such values as these could be obtained by accident is altogether unworthy of consideration. If an oxygen atom is a structure built up of 16 hydrogen atoms, then according to the ordinary theory that mass and weight are strictly additive, the weight of an atom of oxygen should be exactly 16 times the weight of a hydrogen atom. Now, according to the present system of atomic weights the weight of an atom of hydrogen is taken as 1.0078, so the oxygen atom should weigh 16.125. However, it is found to weigh 16.00. The difference between 16.125 and 16.000 is the value of the packing effect, and *if this effect were exactly the same for all of the elements except hydrogen, then the choice of a whole number as the atomic weight of any one of them, would, of necessity, cause all of the other atomic weights*

to be whole numbers. Though this is not quite true, it is seen that the packing effect for oxygen is 0.77 per cent., which is the average packing effect for the twenty-one elements considered (elements of low atomic number). Therefore these elements, which have packing effects equal to that of oxygen, will have whole numbers for their atomic weights. Since, too, the packing effect is very nearly constant, all of these 21 elements will have atomic weights close to whole numbers.

While according to our ordinary experience mass and weight seem to be additive, the question may be raised whether in the formation of atoms, which is a process which is, up to the present time, outside our experience, this is true. There are three remarkable facts to be explained: first, the atomic weights of the lighter elements on the *hydrogen* basis approximate whole numbers; second, the deviations from whole numbers are *negative,* and third, these deviations are practically constant in magnitude.

It has been already stated that according to the work and calculations of Darwin, and of Geiger and Marsden, the nucleus of the atom is extremely minute in comparison with the size of the atom, so that in the nucleus the mass, if the determined dimensions of atoms and their nuclei are at all correct, is many thousand billion times more concentrated than in the atom. If the nucleus is complex, the electromagnetic fields of the charged particles would be extremely closely intermingled in the nucleus, and it would seem reasonable to assume that this would affect the mass, so that the mass of the whole nucleus would not be equal to the sum of the masses of its parts.

Let us take an extremely simple case for calculation, and find how closely packed the charged particles in a nucleus would have to be to cause the observed decrease in weight (0.77 per cent.) which is found for most of the atoms. In making such a calculation, as a guide for our assumptions, we have the observed fact that radioactive atoms shoot out both positively charged alpha particles and negative electrons at such high speeds that it seems probable that they come from the *nucleus of the atom.* The observed relations between the products of the radioactive changes support this idea very strongly indeed. Thus there seem to emerge from the nuclei of complex atoms both positively and negatively charged particles, and the negatively charged particles are found to be negative electrons. This point should be emphasized, since many workers on atomic theory have endeavored to construct their imaginary nucleus of positively charged particles alone.

The simplest case for calculation[2] would then be for a nucleus consisting of one positive and one negative particle. Let the distance between the particles be d, the charges respectively e_1 and e_2, let the velocity of the particles be along the straight line connecting them and equal to u. Then if c is the velocity of light, the particles have a longitudinal momentum which differs from the momentum calculated by ordinary mechanics for electrically neutral particles possessing mass by an amount equal to

$$2\frac{u}{c^2}\cdot\frac{e_1e_2}{d}.$$

This may be called the mutual electromagnetic momentum of such a system of particles. The mutual electromagnetic mass corresponding to this is

$$\Delta m_1 = \frac{2}{c^2}\cdot\frac{e_1e_2}{d} = \frac{2}{c^2}\frac{e^2}{d} \quad \text{since } e_1 = e_2.$$

[2] For this calculation see the following papers by Harkins and Wilson: *Proc. Nat. Acad. Sciences,* 1, 277–78 (1915); *J. Am. Chem. Soc.,* 37, 1373–78 (1915), and *Phil. Mag.,* 30, 725–28 (1915).

The corresponding mass of one particle is

$$m_1 = \frac{2}{3}\frac{e^2}{c^2R},$$

where R is the radius of the electron; so

$$\frac{\Delta m}{m_1} = \frac{3R}{d}.$$

In the application of this last equation, R is to be taken as the radius of the positive electron, since it is assumed that it is the seat of practically all of the mass of the atom. In order to produce a decrease of mass equal to 0.77 per cent., which is the average decrease in weight as calculated from the atomic weights, the two electrons should approach until their distance is 400 times the radius of the positive electron. Thus a packing effect of 0.77 per cent. would be produced by a moderately close packing of the electrons in the nucleus.

The packing effect for oxygen, which has been taken as the basis for our modern atomic weights, is exactly equal to the average value given above. If the number representing the atomic weight of hydrogen on the oxygen basis, 1.0078 is decreased by this percentage amount, it becomes equal to 1.000, so the oxygen system of atomic weights may be considered as a hydrogen system, with hydrogen taken as 1.000, but where the weight of the hydrogen atom is taken *after* it has been subjected to the average packing effect of 0.77 per cent. Thus in going over from the hydrogen to the oxygen system of atomic weights, the chemists who made the change were, without knowing it, making allowance for the average packing effect, for, while the atomic weight of hydrogen is 1.0078, the atoms heavier than hydrogen have atomic weights which are near what they should be if they were built up of units of weight very close to 1.000. On the other hand, this unit of mass must be somewhat variable to give the atomic weights as they are, even although a part of the variation, in some cases, may be due to the inaccuracy with which the atomic weights are known. This leads either to the supposition (1) that the atoms are built up of some unknown elementary substance, of an atomic weight which is slightly variable, but is on the average extremely close to 1.000, and which does not in any case deviate very far from this value, or to the idea (2) which is presented in this paper, that the *nucleus* of a known element is the unit of structure. The atom of this known element has a mass which is close to that of the required unit, and it has been proved that the decrease of mass involved in the formation of a complex atom from hydrogen units is in accord with the electromagnetic theory. The adoption of the first hypothesis would involve much more complicated relations. It would necessitate the existence of another elementary substance with an atomic weight close to that of hydrogen, it would involve a cause for the increase of weight in the formation of some atoms, and a decrease in other cases, and it would also involve the existence of another unit to give the hydrogen atom.

It may be well to consider here the *probability* that the elements from helium to cobalt, atomic numbers 2 to 27, may have atomic weights as close to whole numbers as they are on the oxygen basis, entirely by accident. For example we may calculate the chance that each of the atomic weights should be as close as it is to a whole number, and we find that there is one chance in five thousand billion billion. Another probability is that the sum of the deviations from whole numbers shall not exceed the sum found experimentally. This gives the result that there is one chance in fifteen million. Thus, in the words of Laplace as applied to a calculation of probability in connection with an astronomical problem, that the atoms are built up of units very close to one, "est indiquée avec un pro-

babilité bien supérieure à celle du plus grand nombre des faits historiques sur lesquels on ne se permet aucune doute."

THE ATOMS ARE INTRA-ATOMIC HELIUM-HYDROGEN COMPOUNDS

The atoms of radioactive substances are known to shoot off alpha particles with speeds as high as 20,000 miles per second. These alpha particles carry two positive charges, have an atomic weight of 4.0, and when they are collected and take up negative electrons, give ordinary helium. They may be thought of as the nuclei of helium atoms, and seem to be shot out from the *nucleus* of the more complex atom such as that of radium or thorium. Fig. 1 illustrates the change which occurs in this process. Any special element, such as radium (which is an extremely active solid, with a valence of 2, and belonging therefore to group 2) has its valence reduced by two when the atom ejects an alpha particle (which carries two positive charges), and in this case changes into the inactive gas, radium emanation or niton. The alpha particle has a weight of 4, and niton has an atomic weight which is 222, or four less than that of radium (226). That this is a general rule was discovered by Soddy, and it was verified later by Fajans, Russell, von Hevesy and Fleck.

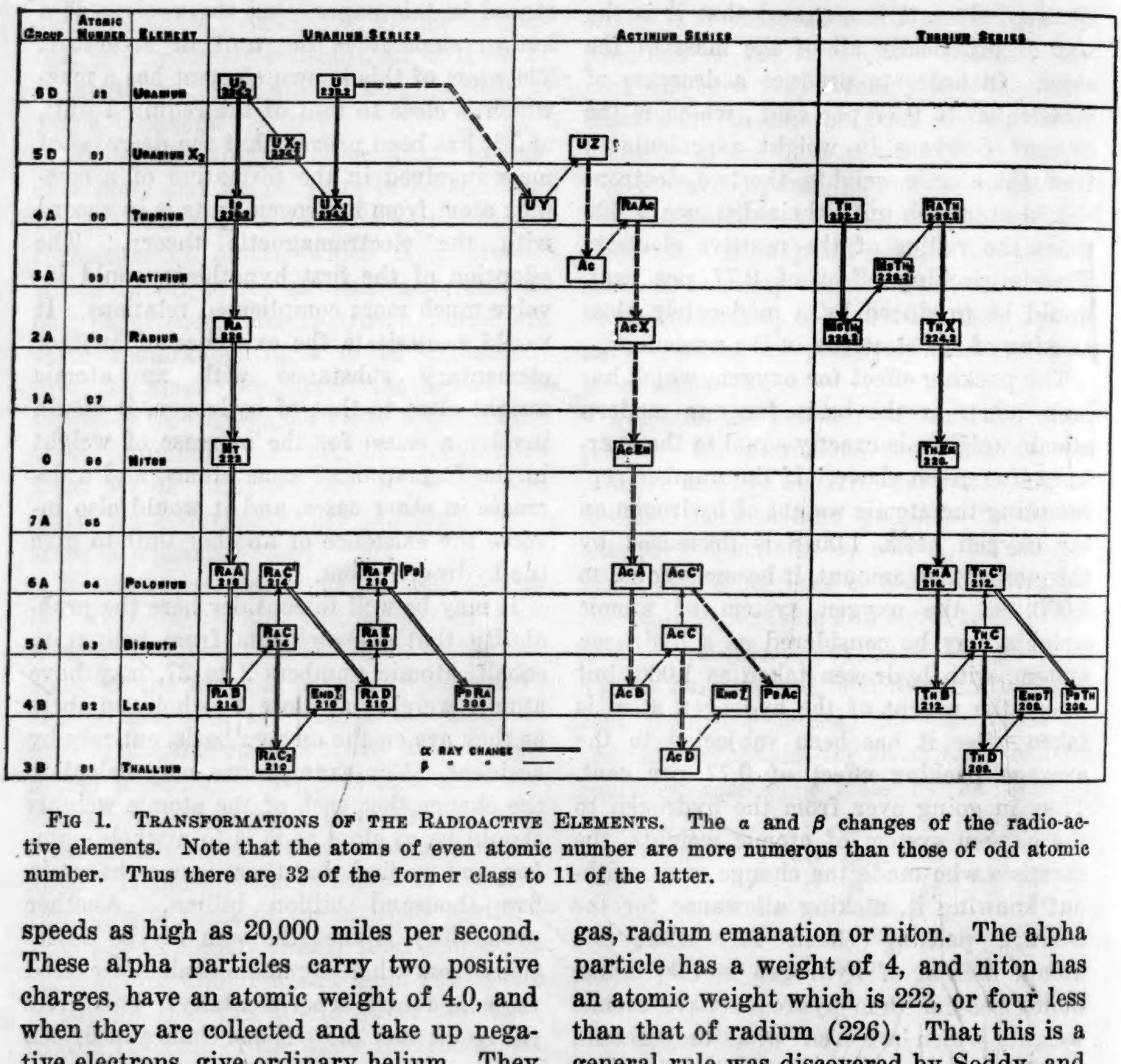

FIG 1. TRANSFORMATIONS OF THE RADIOACTIVE ELEMENTS. The α and β changes of the radio-active elements. Note that the atoms of even atomic number are more numerous than those of odd atomic number. Thus there are 32 of the former class to 11 of the latter.

Let us picture the changes which occur during the long chain of processes which

converts Uranium 2 into Radium B, which is a variety (isotope) of the element lead. We will assume that the nucleus of a uranium 2 atom, so far as its composition, but not its constitution, is concerned, is made up of the nucleus of a Radium B atom (which nucleus we will designate by $(RaB)_n$, where the subscript n denotes that it is the nucleus only), and 5 a^{++} particles, where the two plus signs serve to remind us that the alpha particle carries a double positive charge. Then the changes which occur, beginning with Uranium 2, and ending with Radium B, are such that in each successive change one of these a^{++} particles is emitted by the nucleus.

the fact that there is evidence in the chemical properties that the number of valence electrons decreases by two. According to this idea, when the nucleus shoots out an a^{++} particle, the atom, as a whole, loses an entire helium atom by the time it becomes electrically neutral. That the loss of the negative electrons in alpha disintegrations has not been detected is probably due to the low velocities with which such external electrons leave the outer part of the atom.

THE ELEMENTS OF EVEN ATOMIC NUMBER, OR HELIUM SERIES ELEMENTS

While the alpha disintegrations of atoms are known only among the heaviest atoms,

TABLE[3]

The Changes in the Composition of the Nuclei of Atoms when they eject Alpha Particles (Nuclei of Helium Atoms) of Weight 4, and carrying Two Positive Charges, with Corresponding Changes in the Non-nuclear Electrons

Group	Atomic Number	Name of Element	Atomic Weight	Composition of Nucleus	+ Charge on Nucleus	Number of Inner Non-Nuclear —Electrons	Number of Valence Electrons
6	92	Uranium 2	234	82 + $(RaB)_n + 5\alpha^{++}$	(Note 3) 82 + 10 = 92	86	6
4	90	Ionium	230	82 + $(RaB)_n + 4\alpha^{++}$	82 + 8 = 90	86	4
2	88	Radium	226	82 + $(RaB)_n + 3\alpha^{++}$	82 + 6 = 88	86	2
0	86	Niton	222	82 + $(RaB)_n + 2\alpha^{++}$	82 + 4 = 86	86	0
6	84	Radium A (Isotope of Polonium)	218	82 + $(RaB)_n + 1\alpha^{++}$	82 + 2 = 84	(Decrease here by 8) 78	6
4	82	Radium B	214	82 + $(RaB)_n$	82 + 0 = 82	78	4

According to this table it would seem that when the nucleus of an atom loses an a^{++} particle, and thus decreases its positive charge by two, the outer atom must lose two negative electrons in order to keep the atom electrically neutral. That this is actually the case seems to be indicated by

and extend downward from element ninety-two (uranium) to element eighty-two (lead), it occurred to me several years ago that this system undoubtedly should extend downward still further, and quite possibly even to the lightest elements. The indication that the system still holds should be found in the atomic weights, for these should increase in steps of four between the atoms of even number. Thus the atomic weights of the lighter elements, if *exactly* this same system holds, should be as follows:

[3] The most doubtful feature of this table is the assumption that the nuclear charge is equal to the atomic number, but the insertion of $92 + \mu$ for 92, of $90 + \mu$ for 90, etc., where μ is a whole number, and probably either zero or else very small, removes this doubtful feature.

Atomic Number	Atomic Weight
2	4
4	8
6	12
8	16
10	20
12	24
14	28
16	32

Now, the extremely remarkable fact is that *the atomic weights given above are the atomic weights of the even numbered elements,* with only one exception.

If the twenty-six elements from helium to cobalt (atomic weights from 4 for helium to 59 for cobalt), inclusive, are considered, it might be assumed that the even numbered, or one half of the elements, should have atomic weights divisible by 4. Indeed, while there are two exceptions to the exact system, just 13 of these elements do have such atomic weights, and every possible multiple of 4 but one is taken, as is shown in the following table:

$1 \times 4 =$ helium
$2 \times 4 =$ missing, and replaced by $2 \times 4 + 1$
$3 \times 4 =$ carbon
$4 \times 4 =$ oxygen
$5 \times 4 =$ neon
$6 \times 4 =$ magnesium
$8 \times 4 =$ sulphur
$9 \times 4 =$ missing, but replaced by $10 \times 4 =$ argon
$10 \times 4 =$ calcium
$11 \times 4 =$ scandium
$12 \times 4 =$ titanium
$13 \times 4 =$ chromium
$14 \times 4 =$ iron

Thus, since the *even-numbered* elements of *high atomic weight* give off *helium atoms* when they disintegrate, and in such a way that for each helium atom lost the *heavy atom* changes into the atom of the element which has an *atomic number which is smaller by 2;* and since the *even numbered elements* of *low atomic weight* have *atomic weights which increase by four, or the atomic weight of helium, for each increase of 2 in the atomic number, the natural assumption is that the even numbered elements are compounds of helium.* To distinguish them from chemical compounds they may be called intra-atomic. At least for the elements of low atomic number, their general formula is *nHe'*, where the prime is added to indicate an intra-atomic compound.

THE ELEMENTS OF ODD ATOMIC NUMBER, OR ELEMENTS OF THE HELIUM-H_3 SERIES

If the odd-numbered elements, beginning with atomic number 3, or lithium (atomic weight $= 7$), are built up according to a

TABLE III

The Helium—H_3 System of Atomic Structure $H = 1.0078$

	0	1	2	3	4	5	6	7	8	
At. No.	2	3	4	5	6	7	8	9		
	He	Li	Be	B	C	N	O	F		
Ser. 2..	He	$He + H_3$	$2He + H$	$2He + H_3$	3He	$3He + H_2$	4He	$4He + H_3$		
Theor..	4.00	7.00	9.0	11.0	12.00	14.00	16.00	19.00		
Det. ..	4.00	6.94	9.1	11.0	12.00	14.01	16.00	19.00		
At. No.	10	11	12	13	14	15	16	17		
	Ne	Na	Mg	Al	Si	P	S	Cl		
Ser. 3..	5He	$5He + H_3$	6He	$6He + H_3$	7He	$7He + H_3$	8He	$8He + H_3$		
Theor..	20.0	23.0	24.00	27.0	28.0	31.00	32.00	35.00		
Det. ..	20.0	23.0	24.32	27.1	28.3	31.02	32.07	35.46		
At. No.	18	19	20	21	22	23	24	25	26	27
	A	K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co
Ser. 4..	10He	$9He + H_3$	10He	11He	12He	$12He + H_3$	13He	$13He + H_3$	14He	$14He + H_3$
Theor..	40.0	39.00	40.00	44.0	48.0	51.0	52.0	55.00	56.00	59.00
Det. ..	39.9	39.10	40.07	44.1	48.1	51.0	52.0	54.93	55.84	58.97

Increment from Series 2 to Series $3 = 4$He. Increment from Series 3 to Series $4 = 5$ He (4 He for K and Ca). Increment from Series 4 to Series $5 = 6$He.

similar system, their atomic weights should be as follows:

Atomic Number	Atomic Weight
3	7
5	11
7	15
9	19
11	23
13	27
15	31
17	35
19	39

There is here again the remarkable fact that with one exception these are the atomic weights of the odd-numbered elements. The general formula for the odd-numbered elements may be expressed as $nHe' + H_3'$. From the numerical standpoint it will be seen that the system here proposed corresponds to the formulas found for the atomic weights by Rydberg in 1897. He found that most of the atomic weights can be expressed by $2m$ or $2m - 1$, where m is a whole number.

The proposed structure for the 26 elements of low atomic number is presented in Table III. While it is not meant that in every minute detail this table is necessarily correct, very strong evidence has been found for its validity as a general relationship.

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(*To be continued*)

SCIENTIFIC EVENTS

CHEMICALS AND WAR IN ENGLAND

PROFESSOR W. J. POPE, addressing a meeting of teachers at the Regent-street Polytechnic on October 6, according to a report in the London *Times*, said that Germany prepared for war by the establishment of a huge chemical industry, which was built up about the coal-tar industry, and then by exporting a very large proportion of the world's requirements of coal-tar colors, and pharmaceutical and photographic products.

That success was achieved in spite of the fact that England once possessed the whole of the heavy chemical industry of the world. We formerly produced practically all the nitric and sulphuric acids, and the greater part of the alkali used throughout the world. That had been taken from us as the result of Germany's foresight and exploitation of scientific ability. The coal-tar industry was established originally in this country. Until ten years ago Germany was practically dependent on us for crude coal-tar, and for the simpler first products separated from coal-tar.

Alluding to the establishment of the department for scientific and industrial research with an endowment of £1,000,000, Professor Pope said: The question we want answered is why that experiment was not made twenty years ago, at a time when it would have been undoubtedly successful in preventing the horrors of the last three years? We have suffered in the past from the exclusively British method of making the specialist entirely subservient to the administrator, the administrator being generally chosen because he is available, because he is politically acceptable, and because he knows nothing whatever about the subject which is to be administered and is therefore not likely to be prejudiced by any previous convictions. That process of appointing someone who knows nothing, to supervise the work of some one who does know how to do the job, seems to have been at the bottom of a great many of our misfortunes in the past.

Even in 1915 the government applied this same method to reestablish the coal-tar industry in this country. An organization was established in which all the people in control were men who knew nothing whatever about chemistry or science, and naturally enough the government organization has proved not only a great failure, but has had the further effect of inhibiting the reestablishment of the coal-tar industry. That is to say, the organization apparently was to do everything that was necessary, and consequently private effort was to a considerable extent hampered, and could not get on with the important problem of reestablishing this fine chemical industry.

Such prevalent, but entirely mistaken, activity arises, I think, from a lack of education. If it were generally demanded that no person should be regarded as decently educated who had not mastered the rudimentary principles of natural science and of scientific method, this farce, staged for the amusement of the whole world, in connection with this coal-tar color question, would have been impossible.

The law had absorbed a great proportion of the youth of the nation who were most fitted for a scientific career. The young man who was capable of advancing knowledge, either in science or in any other branch of learning, must be taught to regard it as his duty, not to use his abilities simply for the sake of acquiring an easy and comfortable position in life. Above all, we must prevent the young man of the type I have named from going into such a blind alley occupation as that of the law, with the ultimate prospect of quitting the world, having left nothing behind, and having made no contribution whatever to its progress.

Professor Armstrong, who presided, declared that the present position of chemistry in this country was deplorable, owing to government ignorance and indifference. The Board of Trade had, advisedly and of set purpose, it would seem, put all scientific advice aside, and had taken measures which had not only proved a failure but which had actually retarded the development of the dyestuff industry. The government seems to be bent on putting us back, body and soul, into the hands of the Germans, in so far as the higher interests of chemistry are concerned.

FACULTY CHANGES AT THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY

At the Massachusetts Institute of Technology the faculty changes have introduced some new problems since there has been so much demand by the U. S. government and by industrial corporations related to the war for men of technical skill. So great has been this draft that in the department of electrical engineering one third of the staff has been called away, in mechanical engineering a dozen men have gone into war work while civil engineering, chemistry, naval architecture and the other departments have sustained serious losses. On the other hand, the demands for instruction have not only not decreased, for the registration is but slightly less than normal with much the same distribution through courses, but are to a considerable extent greater, for the institute is furnishing instruction in academic and engineering lines to the schools of aeronautics for the army and the navy, and is carrying on no less than three schools for deck officers and the school for marine engineers.

Changes already announced include the retirement of Professor Charles R. Cross, with the title of professor emeritus, and the appointment of Professor E. B. Wilson, of the department of mathematics, to the chair of mathematical physics and head of the department of physics. Professor C. L. Norton has been appointed professor of industrial physics, and Dr. Charles R. Mann has been appointed professor of education and educational research.

The following is the list of promotions:

Instructor A. L. Goodrich to assistant professor of mechanical drawing and descriptive geometry; Instructors F. L. Hitchcock and Joseph Lipka to assistant professor of mathematics; Instructor H. P. Hollnagel to assistant professor of physics; Instructor R. E. Rogers to assistant professor of English; Assistant A. B. English to instructor in machine tool work; Assistant W. T. Haines to instructor in electrical engineering.

The special lecturers and teachers thus far named are, William S. Franklin in physics and electrical engineering, Eliot Putnam in architectural history, Charles R. Gow on foundations, Edward F. Rockwood on concrete design, and T. W. Sprague on electricity in mining.

The appointments of new men to places in the institute instructing staff include: In civil engineering, James B. Newman to be assistant. In mechanical engineering, Robert DeCourcey Ward, DeWitt M. Taylor, to be instructors; Chester A. Rogers, Andrew J. Ferretti, John A. Lunn, Paul Hatch, and H. C. Parker to be assistants. In mining and metallurgy, Frank H. Ellsworth and William A. Wissler, to be assistants. In architecture, Paul W. Norton to be assistant. In chemistry and chemical engineering, John B. Dickson,

Henry W. Stuckeln, Charles R. Park, Charles M. Wareham; Ralph D. McIntire and Earl P. Stevenson to be instructors, and Roger B. Brown, James F. Maquire, Jr., Alden D. Nute, Chandler T. White, Walter G. Whitman, Edward Zeitfuchs, Louise P. Johnson, Frank F. Hansen, Earle E. Richardson and A. G. Richards to be assistants. Amy Walker to be research assistant in chemistry and Duncan A. MacInnes research associate and Leon Adler, research assistant in physical chemistry. In electrical engineering, Edwin A. Ekdahl, and Clifford E. Lansil, to be assistants. In biology and public health, Dr. Francis H. Slack, to be instructor, and Elmer H. Heath, Jr., to be assistant. In physics, Arthur C. Hardy and Joseph DeL. McManus to be assistants. In naval architecture, P. L. Rhodes to be assistant, and Edwin E. Aldrin, George M. Denkinger and Edward P. Warner, to be assistants in aeronautical engineering. In electrochemistry, Casimiro Lana to be assistant. In mechanical drawing, Charles R. Mabie and Walter C. F. Gartner to be assistants. In mathematics, W. H. Wilson to be instructor. In business management, Erwin H. Schell to be assistant professor. In English and modern languages, Frank L. Hewitt, Penfield Roberts and Arthur L. McCobb to be instructors.

THE UNIVERSITY OF PITTSBURGH AND THE ARMY MEDICAL SERVICE

FORTY-TWO per cent. of the teaching staff of the school of medicine, University of Pittsburgh, have enlisted in the medical service of the government. The following men are in Base Hospital No. 27:

Surgery.—Major Robert T. Miller, professor of surgery; Captain Paul R. Sieber, assistant professor of surgery; Captain Stanley S. Smith, assistant professor of ophthalmology; Captain John R. Simpson, assistant professor of otology; Captain Edward J. McCague, instructor in surgery; First Lieutenant J. W. Robinson, instructor in surgery; Captain Eben W. Fiske, demonstrator in orthopedic surgery; First Lieutenant R. J. Frodey, instructor in gynecology; First Lieutenant John H. Wagner, demonstrator in surgery; First Lieutenant Bender Z. Cashman, instructor in surgery.

Medicine.—Major James D. Heard, professor of medicine; Major T. S. Arbuthnot, associate professor of medicine; Major Howard G. Schleiter, assistant professor of medicine; First Lieutenant R. R. Snowden, instructor in medicine; First Lieutenant A. H. Colwell, instructor in medicine; First Lieutenant C. B. Maits, demonstrator in medicine; First Lieutenant A. P. D'Zmura, demonstrator in medicine.

Laboratory.—Captain H. H. Permar, instructor in pathology; First Lieutenant F. M. Jacob, instructor in immunology.

Registrar.—Captain Edward W. zur Horst, demonstrator in medicine.

The following men from the teaching staff have received commissions in the Medical Officers Reserve Corps:

Dr. R. H. Boots,	Mr. J. Garfield Houston,
Dr. D. Hartin Boyd,	Dr. T. D. Jenny,
Dr. Ewing W. Day,	Dr. H. S. Kenny,
Dr. A. W. Duff,	Dr. F. V. Lichtenfels,
Dr. R. M. Entwisle,	Dr. George C. Johnston,
Dr. Wade Carson,	Dr. M. B. Magoffin,
Dr. S. K. Fenollosa,	Dr. C. H. Marcy,
Dr. J. W. Fredette,	Dr. E. W. Meredith,
Dr. H. C. Flood,	Dr. H. T. Price,
Dr. Carl Goehring,	Dr. R. V. Robinson,
Dr. J. B. Gold,	Dr. David Silver,
Dr. J. P. Griffith,	Dr. H. W. Stevens,
Dr. J. L. Gilmore,	Dr. W. C. White,
Dr. R. T. Hood,	Dr. E. E. Wible.
Dr. F. H. Harrison,	

THE WAR AND NAVY DEPARTMENTS AND THE COAST AND GEODETIC SURVEY

AN executive order has been issued transferring to the service and jurisdiction of the War Department and the Navy Department certain vessels, equipment and personnel of the United States Coast and Geodetic Survey. It reads as follows:

In accordance with the authority vested in me by the "Act to temporarily increase the commissioned and warrant and enlisted strength of the Navy and Marine Corps and for other purposes," approved May 22, 1917, I Woodrow Wilson, President of the United States of America, do hereby declare that a national emergency exists and do direct that there be transferred to the service and jurisdiction of the Navy Department for temporary use the following vessels, including equipment and personal other than commissioned officers thereof: *Surveyor, Isis, Bache.*

Also there shall be transferred to the service and jurisdiction of the Navy Department the following named persons now part of the commissioned personnel of the Coast and Geodetic Survey:

William E. Parker,	Robert F. Luce,
Nicholas H. Heck,	Thomas J. Maher,
Clifford G. Quillian,	Francis G. Engle,
Paul C. Whitney,	Leon O. Colbert,
Francis H. Hardy,	Harry A. Seran,
Raymond S. Patton,	Paul M. Trueblood,
Gilbert T. Rude,	Richard R. Lukens,

Arthur J. Ela,	Ray L. Schoppe,
Arthur Joachims,	Conrad T. Bussell,
Harold A. Cotton,	Leroy P. Raynor,
Alfred L. Giacomini,	Gardiner Luce,
George C. Mattison,	Lyman D. Graham,
Fritz C. Nyland,	Stanley T. Barker,
Eustace S. Walker,	Leo C. Wilder,
Harrison R. Bartlett,	Paul V. Lane,
William V. Hagar,	Wilmer O. Hinkley,
Kenneth T. Adams,	George H. Durgin,
Raymond V. Miller,	Charles K. Green,
Frederic L. Peacock,	George L. Bean.

Also there shall be transferred to the service and jurisdiction of the War Department, and I do hereby appoint and direct that they be commissioned and ordered to active duty as of date of this order, in the Officer's Reserve Corps in the grades set opposite their names, the following named persons now part of the commissioned personnel of the Coast and Geodetic Survey:

John T. Watkins, captain, U. S. R.,
Carey V. Hodgson, captain, U. S. R.,
John H. Peters, captain, U. S. R.,
John D. Powell, first lieutenant, U. S. R.,
Isaiah M. Dailey, first lieutenant, U. S. R.,
Otis W. Swainson, first lieutenant, U. S. R.,
George D. Cowie, first lieutenant, U. S. R.,
Ernest E. Reese, first lieutenant, U. S. R.,
Frank S. Borden, first lieutenant, U. S. R.,
Max Steinberg, first lieutenant, U. S. R.,
Harry T. Kelsh, Jr., first lieutenant, U. S. R.,
Ernest W. Eickelberg, first lieutenant, U. S. R.
Arthur S. Hallberg, first lieutenant, U. S. R.,
William H. Clark, first lieutenant, U. S. R.,
Bert C. Freeman, first lieutenant, U. S. R.,
Raymond A. Wheeler, second lieutenant, U. S. R.,
Andrew C. Witherspoon, second lieutenant, U. S. R.,
Herbert R. Grummann, second lieutenant, U. S. R.,
Roland K. Bennett, second lieutenant, U. S. R.,
Max O. Witherbee, second lieutenant, U. S. R.,
Payson A. Perrin, second lieutenant, U. S. R.,
Aaron L. Shalowitz, second lieutenant, U. S. R.,
Roland D. Horne, second lieutenant, U. S. R.,
Robert J. Hole, second lieutenant, U. S. R.,
Frederick E. Joekel, second lieutenant, U. S. R.,
Harrold W. Pease, second lieutenant, U. S. R.,
Benjamin Galos, second lieutenant, U. S. R.,
John W. Cox, second lieutenant, U. S. R.,
George R. Hartley, second lieutenant, U. S. R.,

Also there shall be transferred to the service and jurisdiction of the War Department, and I do hereby appoint and direct that they be commissioned and ordered to active duty as of date of this order in the Officer's Reserve Corps in the grades set opposite their names, the following named persons now part of the personnel of the Coast and Geodetic Survey:

Edmund P. Ellis, captain, U. S. R.,
James W. McGuire, captain, U. S. R.,
Earl F. Church, first lieutenant, U. S. R.,
Oscar S. Adams, first lieutenant, U. S. R.,
Percy B. Castles, first lieutenant, U. S. R.,
Charles A. Mourhess, first lieutenant, U. S. R.,
Walter D. Lambert, first lieutenant, U. S. R.,
Walter N. McFarland, second lieutenant, U. S. R.,
S. L. Rosenberg, second lieutenant, U. S. R.,
H. S. Rappleye, second lieutenant, U. S. R.

The War and Navy Departments shall return to the service and jurisdiction of the Department of Commerce any or all of the material or personnel of the United States Coast and Geodetic Survey transferred by this order when directed by me so to do.

Woodrow Wilson

The White House,
24 September, 1917

SCIENTIFIC NOTES AND NEWS

Plans are under way for the Pittsburgh meeting of the American Association for the Advancement of Science from December 28 to January 2. The Carnegie Institute, the Carnegie Institute of Technology and the University of Pittsburgh are uniting in preparing to entertain the association. Dr. W. J. Holland, director of the Carnegie Museum, is chairman of the committee on arrangements, and S. B. Linhart, secretary of the University of Pittsburgh, is secretary of the committee. Secretaries of affiliated societies and of other organizations meeting at this time are requested to send to the secretary as soon as possible the approximate number of members of each organization who expect to attend; the time for which meetings are to be arranged; also any social functions which will be included in their plans; and also whether lantern or moving picture equipment will be required for any of these meetings. Information in regard to entertainment, hotel rates, etc., can be secured from the secretary.

The Bell Memorial, erected in honor of Alexander Graham Bell and his invention in 1874, of the telephone, was unveiled on October 21, at Brantford, by the Duke of Devon-

shire, governor general of Canada. Mr. Bell took part in the ceremonies. The memorial is the work of W. S. Allward of Toronto. It is on the Bell homestead, dedicated as the Alexander Graham Bell gardens. W. F. Cockshutt, M.P., originator of the plan, and president of the Bell Memorial Association, described Mr. Bell's work resulting in the sending of the first message over a real line in 1875 between Brantford and Paris, Ont.

The Albert Medal conferred recently on Mr. Orville Wright by the Royal Society was presented to him by Lord Northcliffe on October 27.

Temporary Brigadier-General Auckland Campbell Geddes, M.D., professor of anatomy in McGill University, has had conferred on him the honor of Knight Commander of the Order of the Bath. Dr. Geddes is now director of recruiting in England.

In the department of chemical engineering of the University of Michigan all but one member of the faculty has left for active service. Every effort made by the university to replace them temporarily proved unavailing, owing to the unprecedented demand for men in this branch. The situation became so acute that several manufacturing concerns of the state, who employ expert chemical engineers, and the Michigan Agricultural College came to the aid of the university and it opens with a complete staff in this department. Dr. C. D. Holley, of the White Lead and Color Works, of Detroit, will act as head of the department during the absence of Professor A. H. White. Professor W. Platt Wood, of the chemical engineering faculty of the Michigan Agricultural College, has also been given leave of absence for the entire year. In addition the university has secured the services of J. C. Brier, of the Holland, Michigan, Chemical Company, and C. F. Smart, of the United States Graphite Company, of Saginaw.

A division of the Food Administration under the direction of Charles W. Merrill, of San Francisco, has been created to cover the chemicals involved in the production and conservation of foods. This division will coöperate with the other chemical committees of the government in their activities looking to the control and allocation of chemicals used as insecticides, fertilizers, and in refrigeration and other preservative methods.

Since the opening of the war Professor John Zeleny of the University of Minnesota has been engaged in perfecting devices for submarine detection, and is serving on a board for making practical tests at the submarine base at New London of other devices which have been submitted to the government for the detection of submarines. This work is still in progress.

Dean George B. Frankforter, of the school of chemistry of the University of Minnesota, and a member of the research committee of the Minnesota Public Safety Commission, has been commissioned major in the ordnance department of the army and will be given a leave of absence to attend to the duties of his new position.

Professor Charles W. Cobb, associate professor of mathematics in Amherst College, has been granted leave of absence for one year to enter the aviation work of the government. He will hold a position in the Bureau of Instruction that supervises the teaching in the eight ground schools for aviators.

Major Dana H. Crissy, for four years professor of mathematics at West Point, has been appointed commandant of the government school of aeronautics at Princeton.

Dr. Frank C. Hammond, who is connected with the Samaritan Hospital, has been appointed a member of the board of health of Philadelphia to serve during the absence in France of Dr. Alexander C. Abbott, who entered the Army Medical Corps several months ago.

William H. Warren, professor of chemistry in Wheaton College, Norton, Mass., and captain in the Quartermaster Corps, United States Reserve, has been placed on active duty and stationed at Camp Hancock, Augusta, Ga.

Professor George C. Whipple, of Harvard University, and Professor C.-E. A. Winslow,

of the Medical School of Yale University, have returned from Russia, where they were members of the American Red Cross Mission to assist in the sanitary survey.

Professor Wallace C. Sabine, Harvard exchange professor at Paris last year, has returned to America.

Professor Dr. Theodore Kocher, chief surgeon of the Inselspital, Berne, Switzerland, and professor at the medical faculty of the University of Berne, died on July 27.

UNIVERSITY AND EDUCATIONAL NEWS

The teaching hospital of the University of Nebraska college of medicine was dedicated with appropriate ceremonies on October 17, the principal speaker being Chancellor Avery of the university. The new structure, now in full operation with a capacity of 119 beds, was made possible by three legislative appropriations, $150,000 for the building; $65,000 for equipment and $100,000 for a biennial maintenance.

Professor Henry C. Anderson, of the mechanical engineering department, of the University of Michigan, who has been on leave of absence for the past two years, has been appointed head of the department in place of Professor John R. Allen, who resigned to accept the deanship in the college of engineering at the University of Minnesota.

Professor C. F. Curtis Riley, who has been in charge of the department of biology at the State Normal College, Milwaukee, Wisconsin, for the past four years, has been appointed special lecturer in animal behavior, in the department of forest zoology, at the New York State College of Forestry at Syracuse University.

Dr. L. G. Rowntree, of the University of Minnesota, has declined the deanship of the Illinois school of medicine. His salary at Minnesota has been increased to six thousand dollars and an additional appropriation has been made for the further development of his department of medicine.

Dr. Carl Rosenow (Ph.D., Chicago '17), and Dr. Jacob Kantor (Ph.D. '14, Ph.D. '17, Chicago) have been appointed instructors in the department of psychology of the University of Chicago.

At the college of medicine of the University of Nebraska Dr. Maurice I. Smith, for several years connected with the department of pharmacology at the University of Michigan, has been placed in charge of the department of pharmacology. Mr. J. A. Kittleson, of the University of Minnesota, has accepted the position of assistant professor of anatomy and Dr. S. A. Rubnitz has been made instructor in biochemistry.

At Queen's University, Kingston, Canada, E. Flammer, Ph.D. (Harvard), has been appointed assistant professor of physics; O. F. S. Smith, M.Sc. (Pennsylvania State) has been made lecturer in the same department. In the department of geology, Kirtley F. Mather, Ph.D. (Chicago), has been promoted from associate professor to professor of paleontology.

Dr. Olaf Bergeim of the department of physiological chemistry of Jefferson Medical College, has been promoted to associate in that department.

Dr. A. E. Shipley, Master of Christs College, Cambridge University, has succeeded to the office of vice chancellor of the University, in succession to the Rev. T. C. Fitzpatrick, president of Queen's College.

DISCUSSION AND CORRESPONDENCE

ALGONKIAN BACTERIA AND POPULAR SCIENCE

There are two points in Dr. R. S. Breed's communication of September 7 entitled "Popular Science" to which I would like to call attention.

First, my obvious error in the citation from page 292 of *The Scientific Monthly*. How this *non sequitur* slipped through my reading and that of Dr. I. J. Kligler I do not know. It is a wholly illogical statement which is corrected and replaced in the following sentence of my

recently published work "The Origin and Evolution of Life," where it reads (p. 85) as follows:

The great geologic antiquity even of certain lower forms of bacteria which feed on nitrogen is proved by the discovery, announced by Walcott in 1915, of a species of pre-Paleozoic fossil bacteria attributed to "*Micrococcus*," but probably related rather to the existing *Nitroso coccus*, which derives its nitrogen from ammonium salts.

Perhaps the words "rendered probable" would be more accurate than the word "proved" in the sentence as it stands.

As to the second point, Dr. Breed raises the question whether the fossil markings described by Dr. Walcott in the fossil limestone are actually bacteria. On this point there can be no doubt whatever. Walcott reproduced for comparison an illustration of *Micrococcus* from the Encyclopedia Britannica and referred the Algonkian bacteria to *Micrococcus* sp. undt = species undetermined.

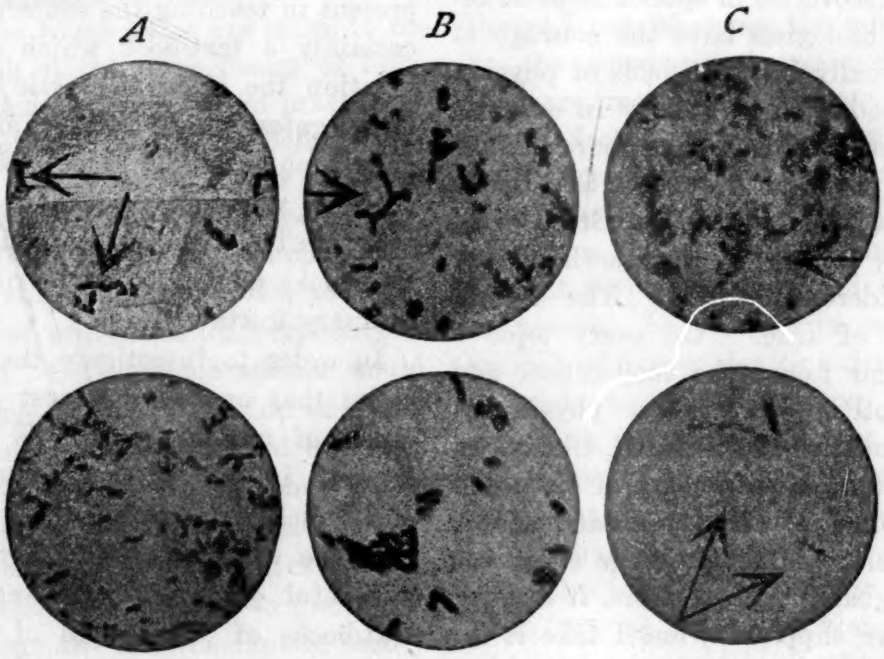
the conclusion that the Algonkian type was closer to the existing *Nitroso coccus*, which derives its nitrogen from ammonium salts, than to *Micrococcus*. The similarity between the Algonkian bacteria (*A*) and some recent forms of nitrifiers (*B, C*) is shown in the comparison of the parts indicated by arrows in the figure.

A comparison of these fossil and recent preparations appears to bear out my statement, made on the authority of Dr. Kligler, that

The cell structure of the Algonkian and of the recent *Nitroso coccus* bacteria is very primitive and uniform in appearance, the protoplasm being naked or unprotected.

Here the word "relatively" might have been inserted.

My entire chapter on bacteria was prepared with the kind cooperation of Dr. I. J. Kligler. Walcott's discovery was cited as indicative of the antiquity of bacteria and my



At my request this very interesting determination by Walcott was taken up by Dr. Kligler, and after a careful investigation he made the series of special preparations of bacteria which are reproduced (*B–F*) in the accompanying figure together with parts of Walcott's two figures (*A*). Dr. Kligler came to

statement was intended to be hypothetical and not categorical. Dr. Breed may be correct in the assumption that the fossil bacterial impressions represent forms related to the denitrifying bacteria and not to the nitrogen fixers or nitrifiers, as Dr. Kligler has suggested. The acceptance of his view would strengthen rather

than weaken the general thesis that bacteria represent a very ancient form of life, for the denitrifying bacteria are generally conceded to be higher in the scale of bacterial life than either the nitrogen fixers or the nitrifiers. If organisms related to the higher denitrifiers existed in the Algonkian, is it not reasonable to assume that simpler forms existed earlier in geologic time? In other words, the hypothetical point as to whether the Algonkian bacteria represent forms related to the nitrifiers or the denitrifiers is immaterial to the conclusion regarding the great antiquity of bacteria.

As to the matter of "popular science" in general the popularizer always runs into danger as soon as he leaves his own special field of research. No one is more conscious of such pitfalls than myself; it is difficult enough to avoid pitfalls in one's own field without venturing into others. At the same time I feel very strongly that little or no progress will be made in the principles of biology (as distinguished from discoveries in special fields of research) unless biologists have the courage to venture occasionally into the fields of physics, chemistry, physiology and zoology in order to look at life from a broader and more distant point of view. Such an attempt I have made in the Hale Lectures which Dr. Breed cites and which now appear in a somewhat more carefully considered form in "The Origin and Evolution of Life." On every topic I have sought and found the cooperation and criticism of other workers—in physics of Pupin, in chemistry of Gies and Clarke, in zoology of Wilson, in astronomy of Hale and Russell, in botany of Goodspeed and Howe, and many others. Although every effort has been made to guard against errors, it may be that others have slipped in, but I take it for granted that specialists will not mistake a popular work for a work of reference nor imagine that I presume to speak with the authority of a specialist in any field but my own.

Henry Fairfield Osborn

THE TEACHING OF OPTICS

The recent discussion in the columns of Science as to the best method to be followed in presenting the fundamental laws and concepts of mechanics to the student has been followed with much interest by teachers of physics. To the writer it seems equally important that attention be directed to another branch of physics, and the question raised as to whether there should not be a radical change in our methods of introducing the student to the subject of optics.

It is generally conceded by those qualified to speak with authority that the establishment of the electromagnetic theory of light represents one of the greatest achievements of modern science. Yet in spite of the far-reaching importance of this principle, the average student who has completed his college course in general physics, or even in many cases more advanced special courses, is entirely unfamiliar with the meaning or the significance of the electromagnetic theory. This need occasion no surprise, however, in view of the methods commonly employed at present in teaching the subject of optics. For certainly a text-book which either does not mention the electromagnetic theory of light or relegates it to a footnote or inconspicuous paragraph is hardly calculated to inspire the student with any great respect for that theory. This criticism applies, not to our text-books alone, but with equal force to the ordinary lecture course.

In order to investigate the justice of this claim that one of the most important principles of modern physics is almost entirely ignored in our present system of teaching and is seldom accorded the attention its importance demands, the writer recently made a careful examination of ten representative text-books of physics, all of them published within the past decade and including practically all, so far as known to the writer, which are very extensively used in our American colleges and universities at the present time. As a result of this examination it was found that in three of these text-books no reference whatever is made to the electromagnetic theory; three other authors content themselves with a bare mention of the theory;

in four of the books an attempt is made to state a few of the more important consequences of the theory, but in practically every case this discussion is limited to one or two paragraphs, either at the very end of the book or at the end of the subject of electricity. (It is a striking fact that nearly all of these authors who deem the electromagnetic theory of light worthy of any comment at all, discuss it, not where we would naturally look for it—under the head of "Light"—but under "Electricity," and then proceed calmly to ignore it when "Light" is taken up!) In only one of the text-books examined is there any attempt at the outset to make clear to the student what light really is or to bring out the fact that there is an intimate connection between optical and electrical phenomena. In not one of the books is the electromagnetic theory made the basis of the treatment of light.

In most of our text-books there is a chapter entitled "The Nature of Light" or "Theories of Light," in which pains are taken to relate the triumph of the wave theory of light over the corpuscular theory, but in practically every case the author stops short before coming to the crux of the whole matter; there is no suggestion as to what kind of waves light waves are. This is a question which is sure to occur to the student, if he be of a normally inquiring turn of mind, but his perplexity is left unanswered. Certainly no teacher would think of omitting from a discussion of sound waves an explanation of what kind of waves sound waves are; yet this is the common procedure when light waves are discussed.

Only two ideas suggest themselves as reasons for the common neglect of so important a principle; either the electromagnetic theory is thought to be not yet sufficiently well established to find a place in our textbooks, or it is thought to be too difficult for the average student to grasp. As to the former, few will question the fact that the theory has been abundantly verified from every point of view and has been firmly established long enough to justify its occupying a prominent place in our text-books and lectures.

The opinion is widely prevalent, however, that the electromagnetic theory presents difficulties so great as to be insuperable for the average college undergraduate. While it may be admitted that the mathematical development of Maxwell's equations and their application to the various cases of reflection, refraction, and dispersion are decidedly beyond the grasp of the average sophomore, yet it is surely possible to present the essentials of the theory in non-mathematical form, and to discuss its more important consequences, as was attempted by the writer in a recent number of *The Scientific Monthly.* As to the vagueness which many feel to be inherent in any attempt to picture a light wave on the electromagnetic theory, we may remark that our conception of an electromagnetic wave is precisely as definite as our ideas of an electric or magnetic field.

It is true that many of the phenomena of light can be given a very simple explanation in terms of the so-called "elastic solid theory," but whatever the advantages offered by the conventional mode of presentation, they are more than counterbalanced by the simple fact that in the light of our present knowledge it is not true to the facts. Certainly our aim in teaching should be to inculcate a knowledge of reality, not of convenient fictions with regard to the processes of nature. In more than one of the textbooks under consideration frequent reference is made to the "vibrating ether particle" which it is assumed serves to transmit a light wave. It would be interesting to know just what sort of a thing an "ether particle" is conceived to be, but quite apart from the absurdity involved in the use of such a term, there can be no doubt that the conception which the expression "vibrating ether particle" tends to fix in the mind of the student is erroneous and misleading. And so with certain other of the stock phrases we have become accustomed to use in dealing with the phenomena of light.

The ideal course in optics, in the opinion of the writer, should be based from first to last upon the electromagnetic theory. A

chapter on electromagnetic waves under the head of "Electricity," in which the nature and chief properties of these waves and their application in wireless telegraphy are briefly discussed, paves the way for a more thoroughgoing discussion of these waves under the head of "Light." From the beginning of his study of light to the end the student should never be allowed to lose sight of the fact that light is essentially an electromagnetic phenomenon; each branch of the subject should be developed on the basis of this theory; and the intimate relationship between the optical properties of a body and its electrical properties should be constantly stressed.

There is perhaps no other branch of science in which the disparity between the point of view of the investigator and that of the elementary student is quite so great as in optics. The modern worker in this field thinks of the phenomena of light in terms of electromagnetic waves and the behavior of electrons under the influence of these waves; to the student, on the other hand, the ideas which form the working basis of the investigator in his researches are meaningless, because he has no knowledge of the theory upon which these depend or of the experimental facts which underlie them. It must be admitted that in all essentials the subject of light is taught to-day very much as it was taught fifty years ago; exactly as we might expect it to be taught if Maxwell had never lived and if the theory which we owe to him had never been suggested. It is to be sincerely hoped that the near future may witness a radical change in this respect, and that those principles which serve as the groundwork of the modern physicist and which guide him in his researches may be correspondingly stressed in our attempts to present the essential facts of optics to the student.

David Vance Guthrie
Louisiana State University

TRANS-PACIFIC AGRICULTURE

Whatever the merits of the particular case, the coincidence between the design called House of Tcuhu in Arizona and the Minoan Labyrinth in Crete, described in Science for June 29, page 677, is of interest as an illustration of a large class of facts in need of the more general scientific consideration that Professor Colton bespeaks. The statement, "There are three possible explanations of the coincidence," needs to be extended. American origin and prehistoric transportation to the old world is a fourth possibility as worthy of consideration as pre-Columbian transfer from the old world to America, introduction with the Spanish conquest, or independent origins in the two hemispheres.

Several cultivated plants of American origin appear to have been carried across the Pacific in prehistoric times, such as the coconut palm, the sweet potato, the bottle gourd, the yam bean, and the Upland species of cotton. The same name for sweet potato, *cumara* or *kumara,* is used by the Indians of the Urubamba valley of southern Peru and by the Polynesians, and other plant names are similar. Moreover, since the migrations of the prehistoric Polynesians extended across the Pacific and Indian Oceans, from Hawaii and Easter Island to New Zealand and Madagascar, it is not unreasonable to look for traces of communication with ancient America in the early civilizations of Asia, Africa or the Mediterannean region.

Agriculture is the primary, fundamental art of civilization, and the evidence of the cultivated plants is the most concrete of any that bears upon the question of prehistoric communication between the more civilized peoples of the two hemispheres. No such significance can be ascribed to the contacts or migrations of non-agricultural people across Bering Strait or the Aleutian Islands. For ethnologists, it may be easy to assume that agriculture had separate beginnings in the old world and the new, but botanists are unable to believe that the same genera and species of cultivated plants originated independently in the two hemispheres, or that they were carried across the Pacific without human assistance.

Peru undoubtedly was the chief center of

domestication and distribution of cultivated plants in America, and in view of this must be considered also as a point of convergence in attempting to trace back to their origins other features of primitive civilization. The large number of domesticated plants and the high development of agriculture in Peru testify even more forcibly than the succession of different styles of Cyclopean architecture to the presence of large agricultural populations in the valleys of the eastern Andes through long periods of time. The ancient reclamation works of Peru challenge comparison with anything that was accomplished in Egypt or Assyria. How far the influence of the ancient Peruvian civilization may have extended in America or elsewhere is a question to which attention may well be given. Pressure of population is a compelling force in the domestication of plants and the development of intensive agriculture, as well as a cause of migration to unoccupied regions. The essential unity of physical types and of agricultural and other arts among the more advanced peoples of ancient America is to be taken into account, as well as the indications of early trans-Pacific communication of agricultural arts and cultivated plants.

It is important to consider all of the archeological and ethnological agreements or coincidences, since these may make it possible to determine the stage of development of civilization in which the prehistoric communication occurred. Whether any particular agreement of words, traditions, or "culture elements" is of real significance is not likely to be determined until such data are brought into relation with facts of other kinds. From the House of Tcuhu in Arizona to the Labyrinth of Minos in Crete, by the way of Peru and Polynesia, is a long journey, but it covers the most practicable routes for the gradual extension of primitive agricultural peoples. That the labyrinth design originated independently in the two hemispheres is as hard to believe as that different people should have identical thumb-prints. If post-Columbian transfer from the Mediterranean region can not be shown, the trans-Pacific route from America to the old world should be considered.

O. F. COOK

BUREAU OF PLANT INDUSTRY,
U. S. DEPARTMENT OF AGRICULTURE,
WASHINGTON, D. C.

BENJAMIN FRANKLIN AND THE STRUGGLE FOR EXISTENCE

THE extent of Benjamin Franklin's mailing address mentioned in the contributions of Dr. Hussakoff and Professor Woodruff in recent issues of SCIENCE is equalled only by the breadth of Franklin's scientific and other interests.

Just as Darwin and Wallace arrived at the theory of natural selection by reading Malthus's essay on the "Principle of Population" so Malthus was prompted to write his essay by reading a very brief contribution of Franklin published in 1751 "Concerning the Increase of Mankind."

Franklin's clear observations on the peopling of the New World led him very surely to the notion of a struggle for existence and the pressure of population on the environment. On these two points Franklin writes as follows:

> There is, in short, no bound to the prolific nature of plants and animals but what is made by their crowding and interfering with each other's means of subsistence. Was the face of the earth vacant of other plants, it might be gradually sowed and overspread with one kind only. as, for instance, with fennel, and were it empty of other inhabitants, it might in a few ages be replenished from one nation only, as, for instance, with Englishmen. Thus there are supposed to be now upwards of 1,000,000 of English souls in North America (though it is thought that scare 80,000 have been brought over sea) and yet, perhaps, there is not one the fewer in Britain.

Regarding the pressure of population, Franklin says in this same essay that America is

> chiefly occupied by Indians who subsist mostly by hunting. But as the hunter, of all men requires the greatest quantity of land from whence to draw his subsistence, the Europeans found America as fully settled as it well could be by hunters.

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SCIENTIFIC BOOKS

The Manufacture of Sulphuric Acid and Alkali with the Collateral Branches. A Theoretical and Practical Treatise. By George Lunge, Ph.D. Fourth edition. *Supplement to Volume I. Sulphuric and Nitric Acid.* New York, D. Van Nostrand Company. 1917. Pp. xii + 347. Price $5.00.

This volume represents rather a new idea in bringing books up to date. The last edition of Lunge's great treatise on sulfuric acid was published in February, 1913. The great advances made along this line, as along almost every line of chemical technology, in the past four years have rendered no little material in the book quite out of date. At the same time a new edition of such a large and expensive work seemed hardly called for. The author and his publishers have found an excellent solution of the problem with which they were confronted by issuing this supplement. All the new matter is printed consecutively with reference to the paging of the original, quite like a volume of footnotes. While the book thus necessarily lacks literary form, to the technological student it is unexpectedly readable, furnishing, as it does, a complete review of the progress of the acid industry for the past four years.

On looking through the book one is struck with the immense amount of work that has been done since the opening of the war, most of it directly occasioned by the inexorable demand for explosives. Sir William Crookes little dreamed, when a few years ago he delivered his now classic address on the wheat supply of the world, that he was making such a world-wide war as the present possible. He saw the peoples of the world rapidly becoming wheat-eaters; the possible wheat lands of the world largely utilized; the only possible source of increased wheat supply a greatly increased production per acre; this increased production only attainable by greatly increased quantities of nitrogen fertilizer; and the only important source of fertilizer, the Chile saltpeter beds, facing exhaustion in a few decades. The clear statement of the problem naturally set chemists at its solution, which of course involved methods of utilizing the inexhaustible supply of atmospheric nitrogen for the manufacture of nitric acid and ammonia. But nitrates are as indispensable for munitions of war as for fertilizer. Ten years ago the other nations would have been helpless at the hands of Germany as soon as their first meager supply of explosives had been shot away, since Germany had foreseen this shortage and long ago "stocked up." On the other hand, had the Chilean niter beds sufficed for the Allies until Germany's supply was exhausted, she would have been at their mercy. Thanks to the stimulus of Sir William Crookes's address, as far as explosives go, the war can continue indefinitely, but after the war the farmer and the wheat-eaters will come to their own, as Sir William intended they should.

The problem of combining atmospheric nitrogen had been commercially solved a few years before the war opened. Lime, saltpeter and nitric acid were being manufactured at Notodden in Norway, and the Rjukanfos, with its 250,000 horse-power, was largely ready for utilization in 1913. Calcium cyanamid was being made at half a dozen plants in different countries, and from this ammonia was easily obtained. The Haber process for combining nitrogen and hydrogen into ammonia was probably being worked commercially in Germany early in 1914, and processes for oxidizing ammonia into nitric acid were becoming available. All of these and numerous lesser processes sufficed to free Germany from dependence on the Chile niter, and the Allies have profited no less.

Equally necessary for munitions is concentrated sulfuric acid, which indeed is demanded in almost every chemical industry, and while the advances in its manufacture have been less striking than has been the case with nitric acid, fully two thirds of the volume is taken up with its progress. These developments have been divided between improvements in the contact process, and the old lead-chamber process, and in the concentration of the chamber acid.

It will interest technologists to know that

the book contains at least brief descriptions of practically all patents bearing on the subject during the period covered by the book, and the information regarding progress in Germany during the war is probably fuller than has elsewhere appeared.

The book contains a full author and subject index, which is particularly valuable, since it includes references both to the original fourth edition and to the supplement.

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AN ENCYCLOPEDIA OF PEACHES

The Peaches of New York. By U. P. HEDRICK, assisted by G. H. HOWE, O. M. TAYLOR and C. B. TUBERGEN. New York Agricultural Experiment Station, Geneva, 1917.

Two comparisons come easily to mind on opening Professor Hedrick's "Peaches of New York." The first is with Poiteau's "Pomologie Française"; the second is with Professor Beach's "Apples of New York."

The beauty of the ripened fruit has always appealed to persons of literary taste and esthetic sensibility, and such persons have often wished to make permanent record of the delights of their gardens and orchards. There have been many notable books, covering more than a century of time, extra-illustrated with colored plates of fruits. The "Pomologie Française" may be mentioned as one of the best early examples of such work.

It might not be much to expect that the "Peaches of New York" would excel any book of a hundred years ago, and yet this standard has been so rarely reached that it is a compliment to say that any one anywhere approaches it. This new book, however, surpasses the old in two fundamental particulars, in the excellence of its plates and in the scientific assemblage of taxonomic data.

Professor Beach's "Apples of New York" comes into the comparison as being the great beginning of this notable series, which now includes the "Grapes of New York," "Plums of New York," and "Cherries of New York." It will be seen that the technical processes of color-photography and printing as applied to this line of work have been greatly improved, even in these last few years, for though the photographing of peaches is much more difficult than the photographing of apples, the color plates of the present volume are emphatically superior. And this point will bear some emphasis, considering how important such plates are as a means of description, and considering that the accurate description of varieties is exactly the main objective of the series.

One must see, too, that the science of systematic pomology has made great progress since the days of Poiteau and Turpin. There have been catalogues of varieties with descriptions and lists of synonyms of course for nearly 200 years, but as a matter of fact the science of systematic pomology is practically a development of the last dozen years. It is, moreover, as yet almost an exclusively American science, having been developed largely by the critical pomological workers in the experiment stations and the United States Department of Agriculture. Professor Hedrick, with his quite unusual facilities and his corps of trained assistants, has been able to bring these modern methods of systematic study to a high degree of perfection. It is not too much to say that, in breadth of view, bibliographic comprehensiveness, and critical examination of detail it would be hard to find better work anywhere in the older fields of taxonomic science.

Emphasis is placed upon the systematic or encyclopedic features of the work, for these are certainly the most important. There are dozens of books and hundreds of bulletins where the reader can more easily find a discussion of how to grow peaches, but the present work will long be the first reference for all those who want the last word on the description or nomenclature of varieties.

The title is of course a brazen misnomer. The book is not limited to the peaches of New York, and probably was never intended to cover any such narrow view. It is a book for the whole United States and the peach-growing portions of Canada. In fact one might better call it "Peaches of the World," for it will doubtless be consulted as widely as Poiteau's fine old book written over seventy years

ago and called by a less provincial name, the "Pomologie Française."

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SPECIAL ARTICLES

COMPARISON OF THE CATALASE CONTENT OF THE BREAST MUSCLE OF WILD PIGEONS AND OF BANTAM CHICKENS

It is now generally accepted that the energy for muscular work is derived from oxidation of the food materials, although physiologists are not agreed as to the means by which the body accomplishes this oxidation at such a low temperature as 39° C., the temperature of the body.

The present investigation was carried out to determine if catalase, an enzyme which liberates oxygen from hydrogen peroxide or from an organic peroxide comparable in structure to hydrogen peroxide, is greater in amount in the breast muscles of wild pigeons accustomed to flying than it is in the breast muscle of bantam chickens not so accustomed; if the catalase content of the breast muscles of the pigeons would be decreased by decreasing the amount of work done by these muscles, and if it would be increased in the breast muscles of the chickens by increasing the amount of work done.

After several wild pigeons and bantam chickens had been washed until free of blood by the use of large quantities of 0.9 per cent. sodium chloride, as was indicated by the fact that the wash water gave no test for catalase, the breast muscles were removed and ground up separately in a hashing machine. One gram of this material was added to 50 c.c. of hydrogen peroxide in a bottle at 22° C., and as the oxygen gas was liberated it was conducted through a rubber tube to an inverted burette previously filled with water. After the volume of oxygen gas, thus collected in ten minutes, was reduced to standard atmospheric pressure the resulting volume was taken as a measure of the amount of catalase in the gram of material. It was found that one gram of the breast muscle of the wild pigeons liberated on an average, 98 c.c. of oxygen, while that of the bantam chickens liberated only about 8 c.c., hence, the amount of catalase in the breast muscle of the wild pigeons is much greater than that of the bantam chickens.

Several wild pigeons were confined for three weeks in individual small cages so that they could not use their breast muscles in flying, while several bantam chickens were made to run and fly until they were almost exhausted once a day for fifteen days. The catalase of the breast muscles of these pigeons and chickens was determined as in the preceding. It was found that confinement decreased the catalase content of the breast muscles of the pigeons by about 40 per cent., while exercise increased that of the breast muscles of the bantam chickens by almost 25 per cent.

The fact that an increase or decrease in the amount of work, and hence in oxidation in a muscle, is accompanied by a corresponding increase or decrease in the amount of catalase, would seem to suggest that catalase may play a rôle in the oxidative processes of the body.

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CILIA IN THE ARTHROPODA

That cilia are absent in the Arthropoda is an assumption which has crept into our zoological literature. Thus, Adam Sedgwick in his "Student's Text-Book of Zoology," Vol. III., 1909, pp. 316–317, says: "These ducts in the female[1] retain a ciliated lining (Gaffron), the only known instance of the occurrence of a ciliated tract among the Arthropoda." Then again, we read in Parker and Haswell's "Text-Book of Zoology," Vol. I., (revised edition), 1910, p. 526, as follows: "Arthropods are also characterized by the almost universal absence of cilia." Kingsley, on page 357 of his revised edition of Hertwig's "Manual of Zoology," 1912, makes the following assertion concerning cilia in the Arthropoda: "The entire absence of cilia is noteworthy. Ciliated cells have never been found in arthropods." Still another zoologist, J. Arthur Thomson in the fifth, revised edition of his

1 Sedgwick is discussing ducts in the female reproductive organs of *Peripatus*.

"Outlines of Zoology," 1913, makes a similar remark. Thomson, in speaking of the characteristics of the Arthropoda, on page 281, says: "Ciliated epithelium is almost always absent."

While working on the structure of the male reproductive organs of certain Decapoda,[2] the author has found good examples of ciliated epithelium in the vasa deferentia of the following forms: the Pacific coast crayfish *Astacus leniusculus,* the Puget Sound hermit crab *Pagurus setosus,* the Atlantic coast lobster, *Homarus americanus,* and the spiny lobster of the California coast, *Panulirus interruptus.*

The vasa deferentia of these crustacea were fixed in various fluids (Hermann's, Flemming's, Bouin's and formaldehyde), and the section were cut 5 μ in thickness. These prepared sections formed the basis for the observations herein recorded. The author tried to tease out the living epithelial cells from the vas deferens of *Astacus leniusculus* in physiological salt solution, Ringer's solution as well as in the body fluids of the crayfish, with a view towards observing ciliary movement in the living cells, but along this line of experimentation little success was met with. In the first place, the heavy secretions of the vas deferens, coupled with the refraction of the cell structures, masks any clear-cut observations. Secondly, the cytoplasm of the epithelial cells is so frail that it goes all to pieces upon the application of the least amount of pressure. The writer had, therefore, to rely solely on the prepared slides. However, these epithelial cells are so distinctly and so characteristically ciliated in the fixed material, that they are very convincing and appear to allow of no other interpretation.

In all the forms mentioned the inner lining of the vas deferens consists of a layer of ciliated epithelium, which is made up mainly of columnar cells. This epithelium is more or less glandular in nature and manufactures a thick, viscid secretion that forms the spermatophoral pouches as well as the sperm-preserving fluid which is commonly found in the Decapoda.

In *Astacus leniusculus* the epithelial lining is more or less uniform throughout the vas deferent tube, while in the other forms it becomes somewhat modified.

In *Paragus setosus,* the epithelial cells become concentrated at one pole of the vas deferens and here they are very much elongated, columnar cells and bear fine examples of cilia. This region of the epithelium seems to be especially adapted for manufacturing the secreting fluid. The lining epithelium of the rest of the vas deferens tube consists of ciliated cuboidal cells.

In *Homarus americanus* the epithelium becomes convoluted in numerous places of the distal end of the vas deferens, thus affording a larger secreting surface. Wherever these convolutions occur, the cells are usually larger, and contain longer cilia than in other regions. Herrick[3] who has made an extensive study of the lobster does not mention ciliated epithelium in the vasa deferentia. In good preparations, the ciliated epithelium is so distinct that one is able to make clear microphotographs of these structures without any difficulty.

In the spiny lobster *Panulirus interruptus,* the finest examples of ciliated epithelium were found. In this crustacean the vas deferens is very long and is lined by an inner layer of ciliated columnar epithelial cells. At one point in the vas deferent tube this epithelial lining dips inward into the cavity of the tube and becomes profusely convoluted into a mass of simple tubular glands. In cross sections, some of these glands may be seen cut across to show the central lumen completely surrounded by the epithelial cells. In such cases, the long cilia are very distinctly seen extending from the free surfaces of the cells into the interior of the lumen.

[2] A fuller account of these studies is soon to appear in the publications of the Puget Sound Marine Station, Vol. No. 26, under the title of "Male Reproductive Organs of Decapoda, with Special Reference to Puget Sound Forms."

[3] Herrick, F. H., "Natural History of the American Lobster," Bull. U. S. Bur. of Fisheries, Vol. XXIX., 1909.

The cilia described in these Decapoda conform in every respect to all authentic descriptions and pictures of cilia which have come under the writer's observation. In many cases, they are short and straight. In other instances they are long and wavy. In still other examples they cluster together to form the so-called brushes. Furthermore, the cilia in all the cases mentioned spring from a well-defined border, and also contain the characteristic basal granules.

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RHYTHMIC BANDING[1]

The formation of Liesegang's rings, known sometimes as "rhythmic banding," is of interest to the geologist and biologist as well as to the chemist. The color arrangement of agate is an excellent example of this phenomenon. Liesegang's original experiments dealt with the rhythmic precipitation of silver dichromate in gelatine. A solution of silver nitrate was poured on a solid gel containing dilute potassium dichromate. The precipitate of silver dichromate formed was not continuous but marked by gaps or empty spaces at regular intervals.

I found it possible to obtain distinct banding of silver dichromate in loosely packed flowers of sulphur. From this and other experiments it is evident that a gel is not absolutely necessary. In practise I found the best medium for sharply marked bands to be silicic acid gel. With this I secured remarkably crystalline banding of mercuric iodide, as many as forty bands in a test tube. Reduced gold in red, blue and green colloidal particles recurring in regular rainbow bands was obtained with a special silicic acid gel.

Basic gels made it possible to secure bands of cupric hydroxide merging into red and yellow forms of cuprous oxide. In a silicic acid gel of slightly basic reaction crystalline basic mercuric chloride formed in very distinct bands. The best banding in the absolute clearness of the gaps was that of copper chromate in a slightly basic gel.

Upon these experiments a new theory may be built. For illustration consider the copper chromate banding.

The gel contains a dilute solution of a chromate and above it in the tube a solution of a copper salt. The copper ions diffuse into the gel, meet the chromate ion and form a layer of insoluble copper chromate at the surface of the gel. The chromate ions immediately below this precipitation zone diffuse into this region now depleted of chromate ions and meet the advancing copper ions thus thickening the layer of copper chromate. According to Fick's law of diffusion the rate of diffusion is greatest where the difference in concentration of the chromate ions in two contiguous layers is greatest, that is, just below the front of this thickening band of copper chromate. As a result the region near the band decreases in concentration of the chromate ions faster than the space below. Finally the copper ions have to advance some distance beyond the band to find such a concentration of chromate ions that the solubility product of copper chromate may be exceeded and a new band formed. This repeats again and again. Of course if the copper ions were retarded sufficiently there would be time for the concentration of the chromate ions again to become uniform throughout the remaining clear gel and no gap would occur. Hence if the diffusion of the copper ions is retarded by any means the clear gaps decrease in depth—the bands are closer together. If copper ferrocyanide bands are formed in similar manner they almost merge after the first layer reaches a thickness of a few cubic centimeters. Yet they are distinct and agate-like. A precipitate of copper ferrocyanide greatly retards the diffusion of the ions that form it, hence we have here the proper condition to reduce the clear gaps to a minimum depth.

The complete paper with working directions and a full exposition of the theory will soon be published elsewhere.

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[1] Abstract of paper read at the Kansas City meeting of the American Chemical Society, April 12, 1917.